CLAIMS

What is claimed is:

1. A system for manipulating a polarizable object using dielectrophoresis, comprising:

a first elongated nanoelectrode electrically coupled with a first time-varying voltage source; and

a second elongated nanoelectrode electrically coupled with a second voltage source, wherein the first and second voltage sources are configured to generate a time-varying electric field between the two nanoelectrodes, and wherein the nanoelectrodes are positioned to allow the dielectrophoretic manipulation of a polarizable object within the electric field.

2. The system of claim 1, wherein the nanoelectrodes each have a first and second end, the first end of the first nanoelectrode being electrically coupled with the first voltage source and the first end of the second nanoelectrode being electrically coupled with the second voltage source.

3. The system of claim 2, wherein the first and second nanoelectrodes are positioned such that the first and second nanoelectrodes extend from the first end to the second end at least partially towards each other, and wherein the second end of the first nanoelectrode is separated from the second end of the second nanoelectrode by a first gap.

4. The system of claim 3, wherein each nanoelectrode is aligned along substantially the same center axis.

5. The system of claim 3, wherein the gap is approximately one nanometer or greater.

6. The system of claim 1, wherein at least one of the nanoelectrodes is cylindrically shaped.

7. The system of claim 6, wherein the cylindrically shaped nanoelectrode is a nanotube.

8. The system of claim 7, wherein the nanotube is a carbon nanotube.

9. The system of claim 8, wherein the carbon nanotube is single-walled.

10. The system of claim 8, wherein the carbon nanotube is multi-walled.

11. The system of claim 1, wherein at least one nanoelectrode is capacitively coupled with the respective voltage source.

12. The system of claim 1, wherein at least one nanoelectrode is electrically coupled with the respective voltage source at a metal electrode.

13. The system of claim 3, further comprising:

a third nanoelectrode having a first and a second end, the first end electrically coupled with a third voltage source; and

a fourth nanoelectrode having a first and a second end, the first end electrically coupled with a fourth voltage source, wherein the second, third and fourth voltage sources are time-varying and wherein each of the nanoelectrodes are arranged radially such that each nanoelectrode extends from the first end to the second end at least partially towards the other nanoelectrodes, the second end of the each of the nanoelectrodes being spaced apart from the others to define a common center region.

14. The system of claim 13, wherein the first and second nanoelectrodes are aligned along substantially the same first center axis and wherein the third and fourth nanoelectrodes are aligned along substantially the same second center axis transverse to the first center axis.

15. The system of claim 13, wherein a polarizable object is located in the common center region.

16. The system of claim 15, wherein the polarizable object is configured to function as a rotor.

17. The system of claim 16, wherein each voltage source is configured to operate at a separate phase to rotate the rotor in a radial direction within the common center region, the phase of each voltage source successively lagging the preceding source in the radial direction.

18. The system of claim 3, wherein the polarizable object is a molecular transistor coupled between the second end of the first nanoelectrode and the second end of the second nanoelectrode.

19. The system of claim 1, wherein the nanoelectrodes and polarized object are suspended in a solution.

20. A method of dielectrophoretically manipulating a polarizable object with elongated nanoelectrodes, comprising:

positioning a polarizable object in proximity with a first and a second elongated nanoelectrode; and

applying a time-varying electric field between the first and second nanoelectrodes, the field being sufficient to manipulate the polarizable object.

21. The method of claim 20, further comprising manipulating the polarizable object into a gap between the first and second nanoelectrodes.

22. The method of claim 21, further comprising trapping the object between the nanoelectrodes.

23. The method of claim 20, wherein the first nanoelectrode extends from a first end electrically coupled with a first time-varying voltage source to a second end and the second nanoelectrode extends from a first end electrically coupled with a second voltage source to a second end in a direction at least partially towards the first nanoelectrode.

24. The method of claim 23, wherein at least one of the nanoelectrodes is cylindrically shaped.

25. The method of claim 24, wherein the cylindrically shaped nanoelectrode is a carbon nanotube.

26. The method of claim 23, wherein the first end of at least one of the nanoelectrodes is capacitively coupled with the respective voltage source.

27. The method of claim 22, further comprising coupling the object between the second ends of the first and second nanoelectrodes.

28. The method of claim 27, wherein the object is a nano-scale circuit device.

29. The method of claim 27, wherein the object is a strand of deoxyribonucleic acid (DNA).

30. The method of claim 27, wherein the object is a peptide nucleic acid (PNA).

31. The method of claim 27, wherein the nanoelectrodes are carbon nanotubes.

32. The method of claim 31, further comprising forming a plurality of carboxyl groups at each of the second ends of the carbon nanotubes.

33. The method of claim 32, further comprising chemically reacting a polarizable object with the carboxyl groups at each second end of the carbon nanotubes.

33. The method of claim 30, further comprising coupling a strand of deoxyribonucleic acid (DNA) into proximity with the PNA, wherein the DNA is complementary to the PNA to form a DNA-PNA duplex.

34. A method of fabricating a carbon nanotube dielectrophoretic system, comprising:

forming a first and a second carbon nanotube, each nanotube having a first and a second end; and

electrically coupling the first nanotube to a first time-varying voltage source and the second nanotube to a second voltage source.

35. The method of claim 34, wherein the first nanotube extends from a first end electrically coupled with a first time-varying voltage source to a second end and the second nanotube extends from a first end electrically coupled with a second voltage source to a second end in a direction at least partially towards the first nanotube.

36. The method of claim 34, wherein forming a first and a second nanotube comprises:

forming a continuous nanotube between a first catalyst site and a second catalyst site; and

separating the continuous nanotube in a location between the two catalyst sites to provide the first and second nanotubes, wherein the first end of the first nanotube is ohmically coupled with the first time-varying voltage source at the first catalyst site and wherein the first end of the second nanotube is ohmically coupled with the second voltage source at the second catalyst site.

37. The method of claim 36, wherein separating the continuous nanotube comprises separating the continuous nanotube with an atomic force microscope.

38. The method of claim 36, wherein the continuous nanotube is formed with chemical vapor deposition (CVD).

39. The method of claim 34, wherein providing the first and second nanotube comprises:

depositing a transition metal on a substrate with an aqueous solvent to form at least two catalyst sites; and

growing the first and second carbon nanotubes from the first and second catalyst sites.

40. The method of claim 39, further comprising lithographically patterning the substrate to form a plurality of wells prior to depositing the transition metal catalysts.

41. A nanowire, comprising:

an elongated nanoelectrode; and

a plurality of polarizable objects coupled with the outer surface of the nanoelectrode.

42. The nanowire of claim 41, wherein the elongated nanoelectrode is a carbon nanotube.

43. The nanowire of claim 41, wherein the polarizable objects are gold nanoparticles.

44. The nanowire of claim 43, wherein the gold nanoparticles have a diameter of approximately 2 nanometers.

45. A method of fabricating a nanowire, comprising:

electrically coupling an elongated nanoelectrode with a time-varying voltage source;

applying a time-varying electric field to the nanoelectrode, the field being sufficient to manipulate a polarizable object in proximity with the nanoelectrode.

46. The method of claim 45, further comprising trapping the polarizable object on the surface of the nanoelectrode.

47. The method of claim 46, further comprising trapping a plurality of objects on the surface of the nanoelectrode such that the nanoelectrode is substantially covered by the objects.

48. The method of claim 47, wherein the nanoelectrode is ohmically coupled with the time-varying voltage source at a first end, and electrically coupled with a second voltage source at a second end.

49. The method of claim 48, wherein the nanoelectrode is a carbon nanotube.

50. The method of claim 48, wherein the plurality of objects are gold nanoparticles.

51. The method of claim 48, wherein the second end is ohmically coupled to the second voltage source.

52. The method of claim 51, wherein the second voltage source is ground.

53. The method of claim 47, wherein the nanoelectrode is capacitively coupled with the voltage source.

54. The method of claim 45, wherein the nanoelectrode is substantially straight.

55. The method of claim 50, further comprising:

forming two electrodes on a substrate; and

forming the carbon nanotube with chemical vapor deposition on the substrate electrically coupling the nanotube.

56. The method of claim 55, further comprising applying a colloidal solution of the gold nanoparticles to the substrate prior to applying the time-varying electric field.